RADAR SAFETY INTERLOCK FOR A REMOTE SENSING SYSTEM

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Abstract

A radar initiated interlock system which protects overflying aircraft from the laser radiation from the remote sensing systems located at Table Mountain Facility of the Jet Propulsion Laboratory is described in detail.

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INTRODUCTION

Outdoor research laser applications can pose significant flight safety hazards through exposure of air crews to light levels which could cause pilot distraction and or create temporary vision impairment. The allowable laser light exposure levels are dependent upon the cockpit workload. These four specific flight zones which are characterized by the typical workload are:

1) Laser/High Intensity Light Free Zone Limit (L/HILFZL), indistinguishable from background ambient light, effectively about 50 nW/cm^2 (CW)*
2) Critical Zone Limit (CZL), will not produce significant visual impairment, 5μW/cm^2 (CW)*
3) Sensitive Zone Limit (SZL), will begin to produce afterimage or flash blindness effects of short duration, 100μW/cm^2 (CW)*
4) Normal Flight Zone Limit (NFZL), normal eye safe power limit, 2.6 mW/cm^2 (CW)*

Pulsed lasers require a correction factor as per ANSI Z136.1. For the majority of lidar systems the initially emitted irradiance is above the maximum power levels for all four flight zones. The spatial volume must be determined where the irradiance is in excess of the critical zone allowable levels.

This critical volume depends on the elevation angle of the laser beam, requiring explicit consideration of the minimum altitude and the minimum horizontal distance based on the laser beam distance. Other parameters which enter the consideration explicitly are the beam divergence, pulse repetition rate, the pulse width, the wavelength, and the irradiance. Another consideration is the estimated distance to the beam that the intruder must travel to intercept the beam between consecutive pulses. This complete scenario describes the volume relative to the laser beam that meets the specification of the appropriate regulations.

SYSTEM

Since the lidar systems at JPL-TMF Facility are operated in a zenith viewing mode, the minimum horizontal distance is essentially zero since it is determined only by the laser divergence, which is less than 1 mrad (0.06°). However, it is still necessary to be certain that the aircraft can be detected and the laser shut down before it reaches the beam. Two different radar systems are available at TMF: an APS-42 and a Primus-40 with pulse repetition rates of 121 and 200 Hz respectively. The radar antennae provide conical power transmission patterns with half-angles ≥2°. Taking the slower radar prf and assuming that the detection circuit requires radar returns on two successive pulses to positively identify an aircraft means that the time required to assert the laser interlock is ≤0.02 s. If one now considers a typical aircraft flying at ~750 $km.hr^{-1}$ (~200 $m.s^{-1}$) it will travel only 4 m into the radar protected zone before the laser is shut down. The size of the zone is of course a function of altitude and the worst case applies for low flying aircraft. For example, at an altitude of 1000 m above the site the diameter of the laser protected area is ~70 m, the laser beam diameter is ~1 m, and the two are close to concentric. Thus, the protected area is almost ten times larger than the minimum required to prevent the laser from hitting the aircraft. This safety margin expands rapidly, and linearly as a function of altitude; for an aircraft at 10 km altitude the safety margin is ~100.

INTERLOCK

The system is designed to detect the intruding aircraft at the edge of the radar antenna power pattern, (essentially a cone) using the radar circuitry. The video signal and the trigger pulse are fed into the interlock circuit, which then senses the increase in the video signal due to the return from the aircraft. The circuit then supplies a voltage at the interlock output terminals which is maintained until the video signal returns to the ambient level. This would indicate that the aircraft had left the critical zone and that laser operation could continue.

In 1988, the first interlock system based on the APS-42 radar was completed and tested. A new installation based on the Primus-40 radar will be installed and tested in the immediate future. The details of the radar safety interlock systems will be presented at the conference.

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REFERENCES

Phillip J. Nessler Jr., "Research Lasers and Air Traffic Safety: Issues, Concerns, and Responsibilities of the Research Community." 19th International Laser Radar Conference, Abstract of Papers. Annapolis, Maryland, USA, pp. 975, July 1998

J. M. Alvarez, R. M. Lawrence, "A Radar Safety Device for Lidar Probing of the Atmosphere," 19th International Laser Radar Conference, Abstract of Papers, Annapolis, Maryland, USA, pp. 983, July 1998

Recommended Interim Guidelines (RIGS) to Supplement FAA Order 7400.2D, Chapter 34, January 26, 1995, NET ftp:ftp.rli.com/pub/RLI/74002d

FAA 7400.2D, Chapter 34, Outdoor Laser/High Intensity Light Demonstrations

American National standards Institute, "American National Standard For Safe Use of Lasers, ANSI Z 136.1", Laser Institute of America, Orlando, Florida (1993)